

Appl. No. 09/851,940
Amdt. dated October 21, 2003
Reply to Office Action of July 21, 2003

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Amendments to the Claims:

Claims 1-24 have been amended. New claims 25-30 have been added. This listing of claims will replace all prior versions, and listings of claims in the application:

Listing of Claims:

- AS
- 1 1. (Currently Amended) A method of analyzing intersections between objects in
2 computer animation comprising the steps of:
3 providing a plurality of objects represented by a plurality of meshes, with each of
4 said plurality of objects being represented by one of said plurality of meshes and each of said
5 meshes being formed by a set of vertices, where a set of pairs of vertices of said set of vertices
6 define a set of edges;
7 checking all edges of said meshes to determine if said set of edges of said meshes
8 intersect with any of said plurality of meshes;
9 tracing an intersection path formed by intersection of said edges with any of said
10 plurality of meshes; and
11 determining which vertices of said meshes are contained within said intersection
12 path; and ~~and setting a polarity of each of said contained vertices to indicate that those vertices~~
13 ~~are contained within said intersection path.~~
14 setting a polarity of each vertex contained within said intersection path to indicate
15 that said vertex is contained within said intersection path, wherein a polarity of a vertex is set
16 based upon a number of disconnected regions formed by said intersection path.
- 1 2. (Currently Amended) ~~[[A]] The method of analyzing intersections between~~
2 ~~objects according to claim 1 wherein said step of determining which vertices of said meshes are~~
3 ~~contained within said intersection path comprises examining vertices of a mesh that contains said~~
4 ~~intersection path within a certain distance from a particular edge of said intersection path and~~
5 ~~characterizing said vertices to determine which vertices of said meshes are contained within said~~
6 ~~intersection path.~~

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3. (Currently Amended) ~~[[A]] The method of analyzing intersections between~~
~~objects according to claim 1 wherein said step of determining which vertices of said meshes are~~
~~contained within said intersection path comprises the steps of:~~
selecting an arbitrary edge of a mesh that crosses said intersection path, where
said arbitrary edge is formed by vertices u and v and where said mesh contains said intersection
path;
performing a search of said mesh, radiating from one of said vertices u and v ,
identifying all vertices in all of said edges that cross said intersection path, and defining the set of
vertices identified as a playpen;
tracing said intersection path and identifying vertices, within said playpen, on a
left side of said intersection path as left and retracing said intersection path in an opposite
direction and identifying vertices, with said playpen, on a right side of said intersection path as
right;
determining whether vertices adjacent to vertices identified as left and right lie
outside of said playpen;
discarding said intersection path when at least one of both left and right identified
vertices lie outside said playpen;
determining whether at least one vertex adjacent to said right identified vertices
lies outside said playpen; and
~~changing said polarity of characterizing each of said left identified vertices to~~
~~indicate that these vertices are as~~ contained within said intersection path when at least one vertex
adjacent to said right identified vertices lies outside said playpen and ~~changing said polarity of~~
~~characterizing each of said right identified vertices to indicate that these vertices are as~~ contained
within said intersection path when at least one vertex adjacent to said left identified vertices lies
outside said playpen.

4. (Currently Amended) ~~[[A]] The method of analyzing intersections between~~
~~objects according to claim 1 wherein said intersection path is a self-intersection with the~~
intersection path being contained in a single mesh and wherein ~~said step of setting a polarity of~~

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4 each vertex of said ~~contained vertices~~ to indicate that those vertices are contained within said
5 ~~intersection path~~ comprises: setting the
6 associating a first color of said vertices that are with each vertex that is contained
7 within said intersection path to a predetermined color when the intersection yields one region;
8 and
9 when the intersection yields first and second disconnected regions, setting the
10 associating a second color of vertices of a first portion of with each vertex contained in said first
11 disconnected region and associating a third color with each vertex contained in the second
12 disconnected region. said single mesh contained within said intersection path to a first color and
13 setting the color of vertices of a second portion of said single mesh contained within said
14 intersection path to a second color when the intersection yields two unconnected regions.

1 5. (Currently Amended) ~~[[A]] The method of analyzing intersections between~~
2 ~~objects according to claim 1 wherein said intersection path is an intersection between a first~~
3 ~~mesh and a second mesh and said step of wherein setting a polarity of each vertex of said~~
4 ~~contained vertices to indicate that those vertices are contained within said intersection path~~
5 ~~comprises setting the~~ associating a first color ~~[[of]]~~ with vertices of the first mesh contained
6 ~~within said intersection path to a first color and setting the~~ associating a second color ~~[[of]]~~ with
7 ~~vertices of the second mesh contained within said intersection path to a second color.~~

1 6. (Currently Amended) ~~[[A]] The method of analyzing intersections between~~
2 ~~objects according to one of claims claim 4 and 5, further comprising displaying said objects on a~~
3 ~~computer display with vertices colored as said vertices have been set~~ displayed in colors
4 associated with the vertices.

1 7. (Currently Amended) A method of determining pinching between objects in
2 computer animation comprising the steps of:
3 providing a plurality of objects represented by a plurality of meshes, with each of
4 said plurality of objects being represented by one of said plurality of meshes and each of said
5 meshes being formed by a set of vertices;

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6 determining an intersection path formed by analyzing intersections between said
7 ~~objects and changing a polarity of each of a plurality of vertices contained in an intersection path~~
8 ~~created by an intersection of said plurality of meshes;~~

9 setting a polarity of each vertex contained within said intersection path based
10 upon a number of disconnected regions formed by said intersection path;

11 selecting a particular vertex of said set of vertices bound between surfaces of said
12 objects and closer to one of said surfaces, where said surfaces have defined insides and outsides
13 and said particular vertex is inside of both surfaces;

14 determining whether any vertices inside of said surfaces have their polarities set;
15 and

16 indicating that said particular vertex is pinched when any vertices inside of said
17 surfaces have their polarities set.

1 8. (Currently Amended) ~~[[A]] The method of determining pinching between~~
2 ~~objects in computer animation according to claim 7 further comprising the step of:~~
3 ~~constraining motion of said pinched particular vertex when motion in said~~
4 ~~computer animation is simulated.~~

1 9. (Currently Amended) ~~[[A]] The method of determining pinching between~~
2 ~~objects in computer animation according to claim 7 wherein said step of changing~~ setting a
3 ~~polarity of each vertex of a plurality of vertices contained in an intersection path comprises setting~~
4 ~~the associating a color of each of a plurality of vertices with each vertex contained in an the~~
5 ~~intersection path, the method and further comprising the step of:~~
6 displaying said objects on a computer display with vertices colored as said
7 ~~vertices have been set~~ displayed in colors associated with the vertices such that an animator can
8 see the intersection and pinching of said objects is visually displayed.

1 10. (Currently Amended) A method of simulating motion of objects in computer
2 animation, the method comprising the steps of:

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3 providing a plurality of objects represented by a plurality of meshes, with each of
4 said plurality of objects being represented by one of said plurality of meshes and each of said
5 meshes being formed by a set of vertices, where at least one of said objects is an animated object
6 and at least one of said objects is a simulated object;

7 positioning said objects at some time t to provide one frame of said computer
8 animation;

9 determining an intersection path formed by analyzing intersections between said
10 objects and setting a polarity of each of a plurality of vertices contained in an intersection path
11 created by an intersection of said plurality of meshes;

12 setting a polarity of each vertex contained within said intersection path based
13 upon a number of disconnected regions formed by said intersection path;

14 setting a simulated force between vertices of said at least one simulated object
15 based on the polarity set for said vertices of said at least one simulated object; and

16 advancing the computer animation to a time $t + \Delta t$ and simulating motions of said
17 objects using said simulated force to simulate motions of said at least one simulated object.

1 11. (Currently Amended) [[A]] ~~The method of simulating motion of objects in~~
2 ~~computer animation according to claim 10 wherein~~

3 when said intersection path is a self-intersection with the intersection path
4 contained in a single mesh, ~~said step of setting a polarity of each vertex contained within said~~
5 ~~polarity of each of said plurality of vertices contained in said intersection path comprises setting the~~
6 associating a first color of with each vertex contained within said intersection path of said
7 plurality of vertices to a predetermined color when the intersection yields one region and when the
8 intersection yields first and second disconnect regions, associating a second color with each
9 vertex contained in said first disconnected region and a third color with each vertex contained in
10 the second disconnected region, setting the color of vertices of a first portion of said single mesh
11 contained within said intersection path to a first color and setting the color of vertices of a second
12 portion of said single mesh contained within said intersection path to a second color when the
13 intersection yields two unconnected regions; and

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14 when said intersection path is an intersection between a first mesh and a second
15 mesh, ~~and said step of setting a polarity of each vertex of said plurality of vertices contained in~~
16 said intersection path comprises ~~setting the~~ associating the second color of each of said plurality
17 vertices of with each vertex of the first mesh contained within said intersection path and
18 associating a third color with each vertex of the second mesh contained within said intersection
19 path, to said first color and setting the color of each of said plurality vertices of the second mesh
20 to said second color.

1 12. (Currently Amended) ~~[[A]] The method of simulating motion of objects in~~
2 ~~computer animation according to claim 11 wherein said step of setting a simulated force between~~
3 ~~vertices of said at least one simulated object comprises:~~

4 setting said simulated force to cause an attraction between vertices of said at least
5 one simulated object when said vertices are ~~set to~~ associated with said ~~first or second or third~~
6 colors;

7 setting said simulated force to cause ~~[[an]]~~ a repulsion between vertices of said at
8 least one simulated object when said vertices are ~~not set to~~ associated with said first color, said
9 second color, or predetermined said third color colors; and

10 setting said simulated force to cause neither an attraction or a repulsion between
11 vertices of said at least one simulated object when said vertices are ~~set to~~ associated with said
12 predetermined first color.

1 13. (Currently Amended) A computer program product ~~comprising, stored on a~~
2 ~~computer usable readable medium having computer readable program code means embodied in~~
3 ~~said medium for causing a computer to manipulate and analyze for processing computer~~
4 ~~generated objects, said computer readable program code means~~ product comprising:

5 means code for providing a plurality of objects represented by a plurality of
6 meshes, with each of said plurality of objects being represented by one of said plurality of
7 meshes and each of said meshes being formed by a set of vertices, where a set of pairs of vertices
8 of said set of vertices define a set of edges;

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9 ~~means code~~ for checking all edges of said meshes to determine if said set of edges
10 of said meshes intersect with any of said plurality of meshes;

11 ~~means code~~ for tracing an intersection path formed by intersection of said edges
12 with any of said plurality of meshes; and

13 ~~means code~~ for determining which vertices of said meshes are contained within
14 said intersection path; ~~and -and setting a polarity of each of said contained vertices to indicate~~
15 ~~that these vertices are contained within said intersection path.~~

16 code for setting a polarity of each vertex contained within said intersection path to
17 indicate that said vertex is contained within said intersection path, wherein a polarity of a vertex
18 is set based upon a number of disconnected regions formed by said intersection path.

1 14. (Currently Amended) [[A]] The computer program product according to of
2 claim 13 wherein ~~said means~~ the code for determining which vertices of said meshes are
3 contained within said intersection path comprises ~~means code~~ for examining vertices of a mesh
4 that contains said intersection path within a certain distance from a particular edge of said
5 intersection path and means for characterizing said vertices to determine which vertices of said
6 meshes are contained within said intersection path.

1 15. (Currently Amended) [[A]] The computer program product according to of
2 claim 13 wherein ~~said means~~ the code for determining which vertices of said meshes are
3 contained within said intersection path comprises:

4 ~~means code~~ for selecting an arbitrary edge of a mesh that crosses said intersection
5 path, where said arbitrary edge is formed by vertices u and v and where said mesh contains said
6 intersection path;

7 ~~means code~~ for performing a search of said mesh, radiating from one of said
8 vertices u and v , identifying all vertices in all of said edges that cross said intersection path, and
9 defining the set of vertices identified as a playpen;

10 ~~means code~~ for tracing said intersection path and identifying vertices, within said
11 playpen, on a left side of said intersection path as left and retracing said intersection path in an

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12 opposite direction and identifying vertices, with said playpen, on a right side of said intersection
13 path as right;

14 means code for determining whether vertices adjacent to vertices identified as left
15 and right lie outside of said playpen;

16 means code for discarding said intersection path when at least one of both left and
17 right identified vertices lie outside said playpen;

18 means code for determining whether at least one vertex adjacent to said right
19 identified vertices lies outside said playpen; and

20 means code for ~~changing said polarity of~~ characterizing each of said left identified
21 vertices ~~to indicate that those vertices are as~~ contained within said intersection path when at least
22 one vertex adjacent to said right identified vertices lies outside said playpen and ~~changing said~~
23 polarity of characterizing each of said right identified vertices ~~to indicate that those vertices are~~
24 as contained within said intersection path when at least one vertex adjacent to said left identified
25 vertices lies outside said playpen.

1 16. (Currently Amended) [[A]] The computer program product according to of
2 claim 13 wherein said intersection path is a self-intersection with the intersection path being
3 contained in a single mesh and said means the code for setting a polarity of each vertex of said
4 contained vertices to indicate that those vertices are contained within said intersection path
5 comprises: means for setting the
6 code for associating a first color of said vertices that are with each vertex that is
7 contained within said intersection path to a predetermined color when the intersection yields one
8 region; and
9 when the intersection yields first and second disconnected regions, means code
10 for setting the associating a second color with each vertex contained in said first disconnected
11 region and associating a third color with each vertex contained in the second disconnected
12 region, of vertices of a first portion of said single mesh contained within said intersection path to
13 a first color and setting the color of vertices of a second portion of said single mesh contained

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14 ~~within said intersection path to a second color when the intersection yields two unconnected~~
15 ~~regions.~~

AS
1 17. (Currently Amended) [[A]] The computer program product according to of
2 claim 13 wherein said intersection path is an intersection between a first mesh and a second mesh
3 and said means of the code for setting a polarity of each vertex of said contained vertices to
4 indicate that those vertices are contained within said intersection path comprises means code for
5 setting the associating a first color [[of]] with vertices of the first mesh contained within said
6 intersection path to a first color and code for associating a second setting the color [[of]] with
7 vertices of the second mesh contained within said intersection path to a second color.

1 18. (Currently Amended) [[A]] The computer program product according to of
2 claim 16 one of claims 16 and 17, further comprising means code for displaying said objects on a
3 computer display with vertices colored as said vertices have been set displayed in colors
4 associated with the vertices.

1 19. (Currently Amended) A computer program product ~~comprising~~ stored on a
2 computer usable readable medium having computer readable program code means embodied in
3 said medium for causing a computer to manipulate and analyze processing computer generated
4 objects in computer animation, said computer readable program product code means comprising:
5 means code for providing a plurality of objects represented by a plurality of
6 meshes, with each of said plurality of objects being represented by one of said plurality of
7 meshes and each of said meshes being formed by a set of vertices;

8 means code for determining an intersection path formed by analyzing
9 intersections between said objects and means for changing a polarity of each of a plurality
10 vertices contained in an intersection path created by an intersection of said plurality of meshes;

11 code for setting a polarity of each vertex contained within said intersection path
12 based upon a number of disconnected regions formed by said intersection path;

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13 means code for selecting a particular vertex of said set of vertices bound between
14 surfaces of said objects and closer to one of said surfaces, where said surfaces have defined
15 insides and outsides and said particular vertex is inside of both surfaces;

16 means code for determining whether any vertices inside of said surfaces have
17 their polarities set; and

18 means code for indicating that said particular vertex is pinched when any vertices
19 inside of said surfaces have their polarities set.

1 20. (Currently Amended) [[A]] The computer program product according to of
2 claim 19 further comprising:

3 means code for constraining motion of said pinched particular vertex when
4 motion in said computer animation is simulated.

1 21. (Currently Amended) [[A]] The computer program product according to of
2 claim 19 wherein ~~said means for changing the code for setting a polarity of each vertex of a~~
3 ~~plurality vertices contained in an said intersection path comprises means code for setting the~~
4 ~~associating a color of each of a plurality vertices with each vertex contained in an said~~
5 ~~intersection path, the computer program product and further comprising[[.]] means code for~~
6 displaying said objects on a computer display with vertices displayed in colors associated with
7 the vertices colored as said vertices have been set such that an animator can see the intersection
8 and pinching of said objects is visually displayed.

1 22. (Currently Amended) A computer program product comprising: stored on a
2 computer readable usable medium having computer readable program code means embodied in
3 ~~said medium for causing a computer to manipulate and analyze for processing computer~~
4 generated objects in computer animation, said computer readable program product code means
5 comprising:

6 means code for providing a plurality of objects represented by a plurality of
7 meshes, with each of said plurality of objects being represented by one of said plurality of

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8 meshes and each of said meshes being formed by a set of vertices, where at least one of said
9 objects is an animated object and at least one of said objects is a simulated object;

AS 10 means code for positioning said objects at some time t to provide one frame of
11 said computer animation;

12 means code for determining an intersection path formed by analyzing
13 intersections between said objects and setting a polarity of each of a plurality vertices contained
14 in an intersection path created by an intersection of said plurality of meshes;

15 code for setting a polarity of each vertex contained within said intersection path
16 based upon a number of disconnected regions formed by said intersection path;

17 means code for setting a simulated force between vertices of said at least one
18 simulated object based on the polarity set for said vertices of said at least one simulated object;
19 and

20 means code for advancing the computer animation to a time $t + \Delta t$ and simulating
21 motions of said objects using said simulated force to simulate motions of said at least one
22 simulated object.

1 23. (Currently Amended) [[A]] The computer program product according to of
2 claim 22 wherein

3 when said intersection path is a self-intersection with the intersection path
4 contained in a single mesh, said means code for setting a polarity of each vertex contained within
5 said polarity of each of said plurality vertices contained in said intersection path comprises
6 means code for associating a first color with each vertex contained within said intersection path
7 setting the color of each of said plurality vertices to a predetermined color when the intersection
8 yields one region and when said intersection path yields first and second disconnected regions,
9 code for associating a second color with each vertex contained in said first disconnected region
10 and a third color with each vertex contained in the second disconnected region, setting the color
11 of vertices of a first portion of said single mesh contained within said intersection path to a first
12 color and setting the color of vertices of a second portion of said single mesh contained within

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13 ~~said intersection path to a second color when the intersection yields two unconnected regions,~~
14 ~~and~~

15 when said intersection path is formed from an intersection between a first mesh
16 and a second mesh, the code for said means for setting a polarity of each vertex of said plurality
17 of vertices contained in said intersection path comprises means code for setting the associating
18 the second color of each of said plurality vertices with each vertex of the first mesh to said first
19 color and setting the associating the third color with of each of said plurality vertices vertex of
20 the second mesh to said second color.

1 24. (Currently Amended) [[A]] The computer program product according to of
2 claim 23 wherein said means for the code for setting a simulated force between vertices of said at
3 least one simulated object comprises:

4 means code for setting said simulated force to cause an attraction between vertices
5 of said at least one simulated object when said vertices are set to associated with said first or
6 second or third colors;

7 means code for setting said simulated force to cause [[an]] a repulsion between
8 vertices of said at least one simulated object when said vertices are not set to associated with said
9 first color, said second color, or predetermined said third color colors; and

10 means code for setting said simulated force to cause neither an attraction or a
11 repulsion between vertices of said at least one simulated object when said vertices are set to
12 associated with said predetermined first color.

1 25. (New) The method of claim 5, further comprising displaying said objects
2 on a computer display with vertices displayed in colors associated with the vertices.

1 26. (New) The computer program product of claim 17, further comprising
2 code for displaying said objects on a computer display with vertices displayed in colors
3 associated with the vertices.

1 27. (New) A method of analyzing intersections, the method comprising:

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2 determining an intersection path formed by an intersection of a first mesh portion
3 and a second mesh portion, wherein each mesh portion comprises a plurality of vertices;
4 determining a set of vertices of the first mesh portion and the second mesh portion
5 that are contained within the intersection path; and
6 setting a value for each vertex in the set of vertices based upon based upon a
7 number of disconnected regions formed by said intersection path.

1 28. (New) The method of claim 27 wherein the first mesh portion and the
2 second mesh portion are portions of a mesh representing an object.

1 29. (New) The method of claim 27 wherein the first mesh portion is a portion
2 of a first mesh representing a first object and the second mesh portion is a portion of a second
3 mesh representing a second object.

30. (New) The method of claim 27 wherein setting a value for each vertex in
the set of vertices comprises:
setting each vertex in the set of vertices to a first value if a single region is formed
by the intersection path; and
if the intersection path forms a first region on the first mesh portion and a second
region on the second mesh portion that is disconnected from the first region,
setting each vertex in the set of vertices that is in the first region to a
second value, and
setting each vertex in the set of vertices that is in the second region to a
third value.

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